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BIOLOGICAL EVALUATION OF NORTH GROVE AND SQUAW HOLLOW CAMPGROUNDS IN CALAVERAS BIG TREES STATE PARK

Report No. 84-07

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ABSTRACT

On the week of April 18, 1983, pathologists and entomologists from the California Department of Forestry and the Forest Service, Region 5, conducted a biological evaluation of the North Grove and Squaw Hollow Campgrounds and the Big Trees nature trail at Calaveras Big Trees State Park. This evaluation was done at the request of the California Department of Parks and Recreation, as a demonstration of what a biological evaluation is, how one is planned and conducted, and how the Department could use one to help meet its management objectives. In both the North Grove and Squaw Hollow Campgrounds, Fomes annosus, true mistletoe, dwarf mistletoe, fir engraver, and various decay fungi in white fir; and western pine beetle and Elytroderma needle disease in ponderosa pine were seen as the major pests. Armillaria root disease of conifers was also seen at Squaw Hollow. In both campgrounds, overstocking and poor or inadequate drainage were seen as predisposing factors which have made and will continue to make the conifers susceptible to attack by bark and engraver beetles and Armillaria. These pest attacks combined with the attributes of the native tree species will result in the gradual conversion of the current mixed oak/pine/white fir/incense-cedar stands into white fir/incense-cedar stands.

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INTRODUCTION

On April 18, 1983, forest pathologists and entomologists from the California Department of Forestry (CDF) and the Forest Service (FS) met with staff from the California Department of Parks and Recreation (CDPR) at Calaveras Big Trees State Park. The purposes of this meeting were 1) to learn about the Department's objectives for the North Grove and Squaw Hollow Campgrounds and specifically what kinds of vegetation they wanted on these recreation sites to support their recreation objectives; 2) to plan the coming biological evaluations of the two campgrounds, including job assignments; and 3) to integrate an on-site pest management training program for selected CDPR and FS personnel into the examinations of the campground pests and vegetation.

Attending this meeting were Craig Engel, Tim Neely, Don Kinney and Chuck Grennell from CDPR; Dave Adams and Dick Hunt from CDF; and Aileen Palmer, John Pronos, Dave Schultz, John Pierce and Dick Smith from the Forest Service.

The vegetation management objectives of the Calaveras Big Trees State Park in these two campgrounds are:

1. Provide for public safety by identifying hazardous trees in the campgrounds and either removing or modifying them or closing that portion of the site to frequent public use. (A tree hazard control program has been practiced on an organized systematic basis in the Park since about 1962.)

2. Maintain the meadow at North Grove Campground.

3. Have stands of trees over the Campground and Campsites which are varied in age and species composition. Favor pines and oaks in these stands.

4. Increase the vegetation screening between Highway 4 and North Grove Campground.

5. Reduce the impact and prevent the establishment of Fomes annosus in the Campground stands. One reason for annosus root disease control is to prevent this pathogen from rendering more trees hazardous.

Calaveras Big Trees State Park is located on the west side of the central Sierra Nevada about 4 miles east of Arnold. The North Grove Campground, elevation 4,700 to 4,800 feet, and the Squaw Hollow Campground, elevation 4,400 to 4,900 feet, are both in the mixed conifer vegetation zone on a highly productive site (Dunning sites 1 and A). Tree species in the campgrounds are ponderosa pine, sugar pine, white fir, incense-cedar, giant sequoia, California black oak, Pacific dogwood and bigleaf maple.

OBSERVATIONS

North Grove Campground

The North Grove Campground is situated around a meadow in several different kinds of forest stands. Following is a brief description of these stands, the important insect and disease pests which were observed, and the stand conditions which were seen that would lead to future insect and/or disease problems of importance. Information on the biology of the pests mentioned here is found in Appendix I. (These stands are outlined on the attached map).

Stand A (Campsites 1 thru 24). This is a young, fast-growing ponderosa pine stand where the overstory pine are mostly 18 to 24 inches dbh. Stocking levels vary, but are generally quite high. There is little understory or brush in this stand except in and around a few openings. A fair amount of top breakage of the overstory has occurred in the recent past. The red turpentine beetle, Dendroctonus valens was seen attacking the butts of several of the pines which were more severely injured by top breakage. The loss of the top and the presence of this beetle indicate that these trees are generally weak and have an increased susceptibility to other bark beetles, such as the western pine beetle, Dendroctonus brevicomis. It is likely that during dry years these weakened trees could act as the foci for mass-attack group kills involving the injured trees and several of the nearest neighbors.

In the lower part of Stand A, in the area of campsites 20 and 21 the overstocking becomes quite pronounced due to the development of a thick pole-size incense-cedar understory. These are the kinds of stand conditions that lead to severe tree stress and to bark beetle attack of the pine overstory.

In the area of site 24 the many stumps and the crowns of some of the living trees indicate a chronic mortality problem. No root diseases were found, but the area is quite wet and boggy and has a drainage problem. The excess water is coming from the direction of Highway 4, which is close by and may be the cause of excessive water.

Stand B (sites 26 to 32). This is a mixed species 3-storied stand. West of the road toward Highway 4 there are scattered old-growth pine and cedar 40 inches and larger in diameter. Under and around the old-growth monarchs are young stands of incense-cedar and firs 6-12" dbh. The cedar/fir understory in places is quite dense and will, particularly in dry years, put considerable stress upon itself and the old-growth monarchs. The old-growth pine under these conditions are susceptible to bark beetle attack. Between the road and the stream there is a stand of 18-24" dbh ponderosa pine with a few groups which are overstocked, and there are some signs of red turpentine beetle activity in the butts of the weaker trees.

Stand C (sites 33 to 37, 45, and 46). This is a heavily stocked stand of mixed conifers about 12 to 24" dbh. Little understory and/or brush is found under this thick canopy except at the margins of the openings.

Some incense-cedar mortality of unknown causes was seen between this area and the pump house. Some leaning trees and snags hung up in other trees may represent a hazard to the recreationists in this area. Polyporus schweinitzii, a root and butt decay-causing fungus, was found fruiting in the neighborhood of site 36 next to two recently cut stumps. There was no sign of stress in the adjacent trees, but they should be watched for signs of crown thinning. Such crown thinning would be an indicator of severe root and/or butt decay.

Stand D (Campsites 47 through 57). This is a multistoried stand of white fir with some incense-cedar. The overstory is old-growth white fir 24" dbh and larger. The understory is white fir and a few incense-cedars from 6" to 12" dbh. On the western margin of this area (campsites 50, 52, and 53) there are some very dense stands of saplings and small poles, heavy to incense-cedar. The old-growth white fir in this western portion are infected with dwarf mistletoe, Arceuthobium abietinum, and have some rather large open bole cankers or swellings. These open cankers are most likely infected with wood decay fungi and if so are structurally weakened and could be hazardous.

The area of Stand D within the loop of the road is infested with annosus root disease, caused by Fomes annosus, and by true mistletoe, Phoradendron bolleanum spp. pauciflorum. Annosus root disease, in combination with the fir engraver, Scolytus ventralis, has killed several trees in this area within the past decade and has created a couple of fairly large openings in the stand.

Stand E (Site 42 and east of the road). This is an old oak stand which is now being overtopped by a mixture of cedar, fir and pine about 8-16" dbh. The western portion of this stand next to the meadow is an older mixed conifer stand 18-30" dbh with a few old-growth monarchs, particularly around site 59. This stand is overstocked in places. Next to the meadow the tops of several ponderosa pine have been broken out, and they have an increased susceptibility to bark beetles.

Stand F (Sites 50 to 74 and picnic area). This is a mixed old-growth and large second-growth stand of white fir with scattered ponderosa and sugar pine, and incense-cedar. In the upper sites (69 to 74) the stand has broken up enough to allow the establishiment of an understory of pole-sized fir. This area also has a fair number of dogwood. The white fir in this area are infested with both true and dwarf mistletoes. Large dwarf mistletoe-caused bole cankers, many of which are open to decay, are common in white fir. The true mistletoe and fir engraver infestations have resulted in the death of the tops of many white fir. Large fire scars were found in and around the bases of many of the true fir and other conifers. Wood decay was most often associated with these fire scars in white fir. Several old monarchs in the area are close to death. Much of the area is overstocked, so during dry years the reduced vigor resulting from competition could result in tree mortality. This is particularly true of the sugar pine and the true mistletoe-infected white fir. Some of the dogwood around sites 69 and 70 were suffering from a canker disease.

General Observations

The parking spurs were unpaved and the actual parking of vehicles within the parking area is not regulated. This could result in vehicles being parked on the soil close to surrounding trees, causing root injury and soil compaction. Root injuries are entrance courts for decay leading to possible tree failure. Soil compaction lessens the water penetration and storage capacity in the soil, which in dry years will result in higher tree stresses and increased susceptibility to bark beetle attack.

A review of campsite location and possible removal or relocation of some sites may be in order, to achieve better spacing and reduce the impact of public use on some trees.

MANAGEMENT ALTERNATIVES - NORTH GROVE

Alternative 1. No Vegetation Management. This is the current management practice, where dead and hazardous trees or hazardous parts of trees are removed to provide for public safety. No attempts at modifying the vegetative cover is made for other reasons. Under this alternative the trees in the campgrounds will continue to grow, competition between trees will increase as they grow, leading to higher levels of tree stress during dry periods. Bark beetle attacks will increase, particularly during dry years, and these insects will kill individuals and groups of trees, particularly pines in overstocked stands and white firs that are diseased. This is the natural successional trend in this forest type where the intolerant pine-oak stands are replaced by a more tolerant white fir-incense-cedar stand.

In stand A, bark beetle attacks will probably center in the near future on those pines with severe top breakage. The attacks on some of these broken trees could enlarge to include some of the surrounding pines, particularly if the attack occurs in a dry year when they are stressed. Eventually, bark beetles will open holes in this stand, and incense-cedar and white fir will become established as the understory. This shift is apparent in and around campsites 20 and 21 where a thick understory of incense-cedar has become established. This thick cedar pole-sized stand will stress the overstory pine stand during dry summers and increase their susceptibility to bark beetles. Losses in the boggy area (campsite 24) will continue.

In Stand B, the young developing stand of incense-cedar and white fir will put increasing stress on the old-growth pines in the area, increasing the pines' susceptibility to bark beetles. In turn, the old pine overstory will continue to suppress the development of the young developing cedar stand. The part of this stand next to the meadow is overstocked in places and contains a few weak individuals, both of which increase the probability of bark beetle attack in this area.

In Stand C, some bark beetle-caused losses due to overstocking and stress will occur - again, most likely during a dry year. The stress will occur in all species of trees, but because the pine bark beetles

are more aggressive, the pines will be the trees to die and the composition of the stand will change to include more incense-cedar and white fir.

In Stand D around sites 50, 52, and 53, bole failures of mature white fir with large dwarf mistletoe-caused bole cankers is probable. Within the loop road, mortality of white fir due to Fomes annosus, fir engraver, and true mistletoe will continue. The opening within the stand will increase in size. A moderate to high probability of tree failure, due to annosus root decay, exists. The thin-crowned firs are the most likely to die or fail. An understory of incense-cedar and white fir will be released. The released white fir in all probability are already or soon will be infected by Fomes annosus. We are unsure of the probability of the incense cedar becoming infected.

The oaks in Stand E are being over-topped by pines and cedars, and will be gradually shaded out. The overstocked conifer stands next to the meadow will probably experience some pine mortality. The pines with broken tops will be particularly susceptible to bark beetle attack.

In Stand F, mortality of the white fir with severe infections of true mistletoe is likely. Some hazard from the white fir with large basal fire scars exists. Some tree failure of those white fir with old dwarf mistletoe bole cankers will occur. Mortality of sugar pine in competition with fir and cedar in overstocked stands will occur with time.

Alternative No. 2. Selective Removal of Trees to Meet Stand Management Objectives. Under this alternative selected trees would be removed to lower the stand density and reduce stresses to a level where the trees and stand would be more resistant to bark beetle attacks. Hazardous trees and heavily diseased and damaged trees which are predisposed to bark beetle attack would also be removed. In selecting trees for removal, one must consider the need to retain a given tree for recreation or aesthetic purposes and balance the benefits of retention against the benefits of removal. In selecting the trees to be removed or kept in the stand, a priority selection system similar to the following could be used to remove trees to achieve desired stand densities:

1. Remove the most hazardous trees.

2. Remove diseased, bark beetle-infested, and damaged trees with the highest probability of dying (top kills, snow breakage, severely mistletoe-infected, and bark beetle-attacked trees).

3. Select the most desirable trees to keep in the stands; remove those adjacent trees which are less desirable.

Apply this treatment to small groups of trees, campsite by campsite, making decisions on the basis of the group which exists at each site and the management objectives for that particular site.

The results of this management alternative would be a decrease in the incidence of hazardous trees, a reduction of uncontrolled mortality of desirable trees, and the continuation of stands with a greater diversity of species and age-classes.

Also, applying this alternative would prevent and/or reduce future pest-caused losses of desirable recreation trees. The possible increase of annosus root disease, resulting from the infection of newly cut stumps, would be prevented by the treatment of all freshly-cut conifer stumps with borax within 8 hours of cutting. Losses from pine engraver beetles would be prevented by the prompt removal and/or treatment (chipping, burning, crushing) of all pine slash within 4 weeks of its creation.

The individual stands (A through F) would be treated as described in the following.

Stand A. Those pines with severe snow damage and or pest attacks, would be removed and the remaining overstocked pine stand would be thinned, leaving the most vigorously growing pines at the desired locations. The thick understory of cedar and fir would be heavily thinned, leaving only enough of this understory to provide the desired screening. (Widely spaced cedar and fir maintain their foliage to the ground and will provide better screening for a longer period than will thick stands which self prune and lose the lower branches.) The source of excess water causing the flooding at sites 24 and 25 would be identified and its current course would be changed, modified, or channeled to reduce the size of the flooded area and the length of the flooding period. These treatments, in combination, will lower the bark beetle losses, which will occur during periods of drought and stand stress, and decrease the mortality in the boggy area in the future.

Stand B. Either the old-growth monarch trees or the young understory trees could be selected as the desired vegetation for the site and the other component removed to lower the competitive stresses in the stand. If the young stand is selected, it should be further thinned to reduce future stresses and maintain full crowns. The selected removal of pest-damaged trees and less vigorous trees in overstocked groups next to the meadow would lower bark beetle losses in this part of the stand.

Stand C. A thinning of the intermediate, less vigorous trees would be done to decrease stand density, increase vigor and lower periodic stress. The retention of pine could be emphasized, to increase the amount of pine in the stand and offset the successional trend toward the more tolerant white fir and cedar. The decrease in drought stress and removal of less vigorous trees would reduce future bark beetle-caused losses.

Stand D. The overstory white fir with dwarf mistletoe-caused bole cankers would be removed and the thickets of sapling conifers would be thinned, selecting for pine and cedar. These actions would decrease the probability of tree failure from the bole cankers, would lower the stress on overstory trees competing with dense understories, and would guide the understory development toward the desired species and densities, while maintaining foliage screening for a longer period.

In the annosus root disease center within the loop, the current white fir stand would be eliminated and converted to a pine/oak/cedar stand. This species change is suggested as a means of reducing future hazardous tree problems which are associated with annosus root disease in white fir. This could be accomplished in different ways and rates, depending upon the objectives of the Park. On the one hand, a rapid conversion could be accomplished by the removal of all stressed fir (as evidenced by poor growth, dead tops, thin crowns) and all understory fir. Any cedar and pine in this area would be released and the more open areas would be planted to pine (sugar or ponderosa), oak, and cedar. At intervals over the years more white fir would be removed as they start to decline. On the other hand, a much slower rate of conversion would be accomplished by removing the white fir as they die or become hazardous and planting the larger openings to the appropriate species. The change from a predominantly white fir stand to a mixed pine/oak/cedar stand would not only greatly reduce the impact of annosus root disease on this area but would also eliminate the fir dwarf mistletoe and true mistletoe problems of this area, since both pests are restricted to white fir and would not effect the pine, oak, or cedar.

Stand E. The conifers growing up through or overtopping the oaks would be removed, to keep the oaks in the stand. The overstocked conifer stand next to the meadow would be thinned by first removing the pines with broken tops. This would reduce the risk of future mortality due to bark beetles.

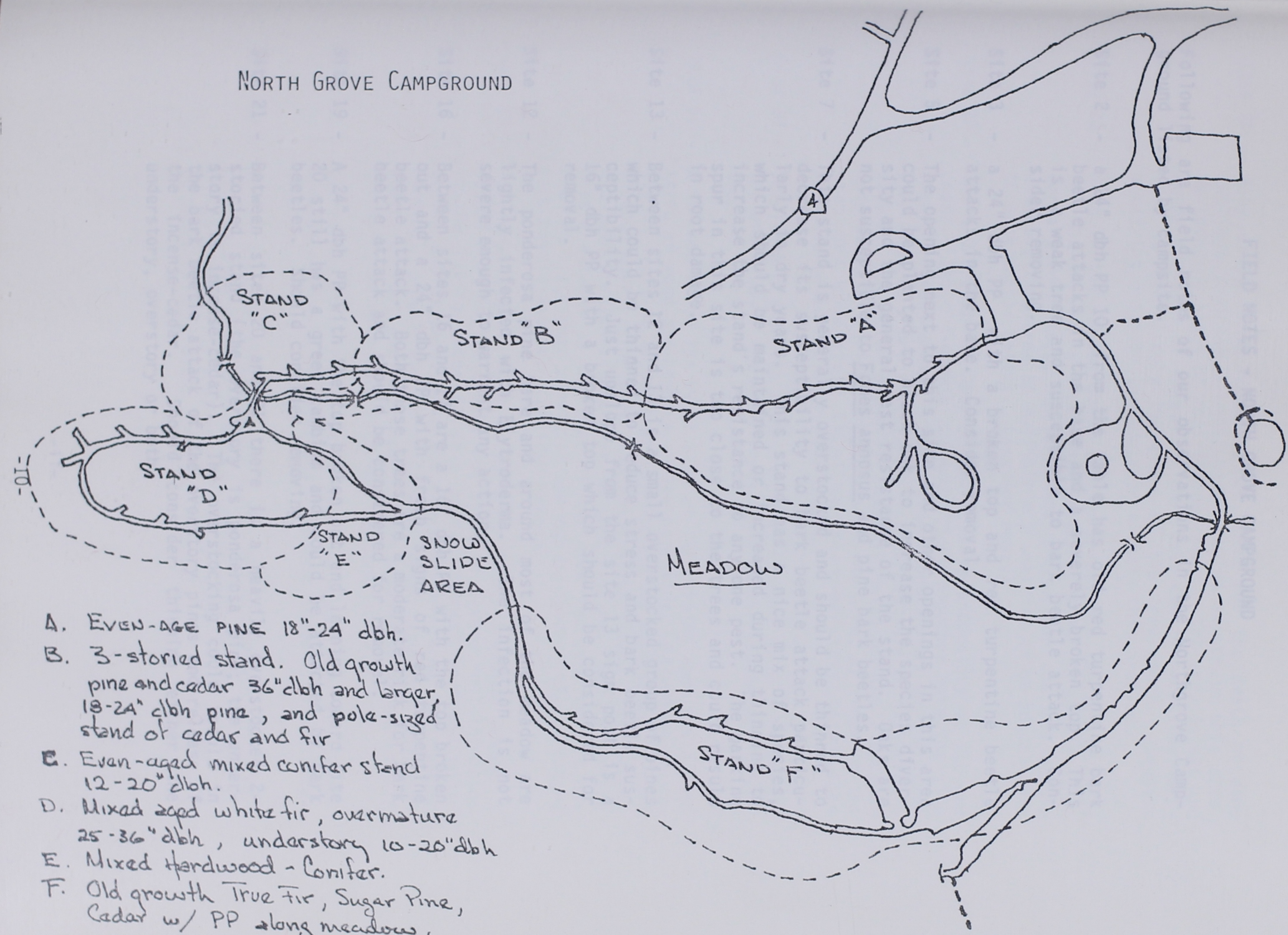
Stand F. A long-term conversion of a predominantly old-growth white fir stand, which has one of the highest hazard ratings, to a less hazardous, more vigorous stand of mixed age classes and species would be accomplished by removing heavily diseased, damaged, and hazardous white fir to open the stand and to release the more desirable pines, particularly the sugar pines, which appear well adapted to this site. An opening of the stand might also benefit the dogwood there. The younger healthy cedar and white fir would also be kept in the stand. The old-growth trees with large fire scars - particularly the white fir - also would be removed.

Alternative No. 3. Selective Removal of Trees and Planting of Trees and Shrubs to Meet Stand Management Objectives.

The overstocked condition of most stands in this campground has shaded out any understory trees and brush which would provide screening around and between campsites. In other cases the old-growth stand is declining and leaving holes in the stand which are not being regenerated naturally. The natural regeneration now present is mostly cedar and white fir. White fir is generally more prone to failure than pines and oaks; thus, this new stand will be more hazardous than a young stand of mixed oak, pines, cedar and white fir. A mixed stand is generally more resistant to damage by pests and is less damaged by any one pest which becomes established.

Thus, as the stands of North Grove are opened up by the selective removal of trees as indicated in Alternative 2, trees, mostly pines and oaks, would be planted where desirable in the larger openings and cedar in the smaller openings. Brush to provide screening and control traffic would be planted in and around the campsites where the overstory had been sufficiently opened to provide the light needed for their survival.

North Grove Campground



A. Even-age pine 18"-24" dbh.
B. 3-storied stand. Old growth pine and cedar 36" dbh and larger, 18-24" dbh pine, and pole-sized stand of cedar and fir
C. Even-aged mixed conifer stand 12-20" dbh.
D. Mixed aged white fir, overmature 25-36" dbh, understory 10-20" dbh
E. Mixed Hardwood - Conifer.
F. Old growth True Fir, Sugar Pine, Cedar w/ PP along meadow.

FIELD NOTES - NORTH GROVE CAMPGROUND

Following are field notes of our observations in the Northgrove Campground listed by campsite.

Site 2 - a 24" dbh PP 10' from the table has old red turpentine bark beetle attacks in the base and a severely broken top. This is a weak tree and susceptible to bark beetle attack. Consider removing.

Site 3 - a 24" dbh PP with a broken top and red turpentine beetle attacks in the base. Consider removal.

Site 5 - The opening next to this site and other openings in this area could be planted to black oak to increase the species diversity and the general pest resistance of the stand. Oaks are not susceptible to Fomes annosus and pine bark beetles.

Site 7 - This stand is generally overstocked and should be thinned to decrease its susceptibility to bark beetle attack particularly in dry years. This stand has a nice mix of species, which should be maintained or increased during thinning to increase the stand's resistance to any one pest. The parking spur in this site is too close to the trees and could result in root damage.

Site 13 - Between sites 12 and 13 is a small overstocked group of pines which could be thinned to reduce stress and bark beetle susceptibility. Just upslope from the site 13 sign post is a 16" dbh PP with a broken top which should be considered for removal.

Site 12 - The ponderosa pine here and around most of the meadow are lightly infected with Elytroderma. The infection is not severe enough to warrant any action.

Site 16 - Between sites 16 and 17 are a 16" dbh PP with the top broken out and a 24" dbh PP with fresh signs of red turpentine beetle attack. Both these trees are a moderate risk for bark beetle attack and should be considered for removal.

Site 19 - A 24" dbh PP with the top broken out and leaning toward Site 20 still has a green cambium and could be attacked by bark beetles. Should consider removing.

Site 21 - Between sites 20 and 21 there is a heavily overstocked 2-storied stand (the overstory is ponderosa pine; the understory is incense-cedar). The overstocking could result in the bark beetle attack of the overstory pines and release of the incense-cedar. Should consider thinning either the understory, overstory or both.

Site 24 - Many stumps from recently cut trees and the death of some saplings indicate a continuing problem exists in this area. We found no signs of root disease fungi. The area is wet and boggy and lack of oxygen to the roots due to excessive moisture is most likely the cause of the tree death. Suggest modifying drainage to reduce or elimate this problem.

Site 23 - Next to the meadow about 20' upstream from the bridge is a 24" dbh PP with a broken top which is infected with Elytroderma needle cast. Between the broken top and the needle disease, this tree is sufficiently weakened to be susceptible to bark beetle attack. Consider removal.

Site 27 - The old-growth 70" dbh PP has a heavy understory of fir and cedar. The old-growth and understory together make the site severely overstocked. This puts enough stress on the large pine that in a dry year it will be susceptible to bark beetle attack. Consider either a heavy thinning of the fir/cedar understory to relieve the stress on the pine, or removing the pine and moderately thinning the understory to release selected cedar/fir as future stand.

Site 30 - The large old-growth cedar has what appears to be a hazardous top and limbs. Consider removing or modifying hazard condition.

Site 31 - A 20" dbh PP on the right side of the parking spur has a dead strip of wood and cambium on the back side. Polyporus volvatus is fruiting on this strip, indicating that there is some sapwood decay. The tree also has a slight lean. This saprot and lean predispose the tree to stem failure. Red turpentine beetle attacks at the base of the tree indicate that it has been in a stressed condition and may be susceptible to future bark beetle attack. Consider removal.

Site 36 - Polyporus schweinitzii conks were found fruiting around 2 stumps next to the creek. No signs of severe root infection in the living trees in this area. Suggest periodic monitoring and inspection of the trees in this area for reduced terminal growth and thin crowns, which indicate advanced stages of root and butt decay. Some pole-sized incense-cedar are dying between this site and the pump house.

Site 50 - Two forked white fir 15 yards down the road. One is heavily broomed and could be hazardous. Suggest inspection of situation.

Site 52 - At the back of this site is a 40" dbh old-growth white fir with an open dwarf mistletoe - caused bole canker. There is a high probability that there is decay within this canker and it could be hazardous. Consider removal.

Site 53 - There is a heavy thicket of incense-cedar saplings under and around the overstory pines. This understory will eventually stress the overstory. The understory trees are now at a stage where they could be heavily thinned but still have enough low foliage to provide good screening. Consider thinning this understory.

Site 56 - A 30" dbh white fir behind this site has a widow-maker hung up in the crotch. The old-growth white fir surrounding this site are fire scarred and some show signs of carpenter ant activity. Suggest boring the trees to evaluate hazard.

Sites 38, 47, 48, 49, 51, 54, 55 and 57 - The area occupied by these sites and the areas between them are infested with annosus root disease and true mistletoe. The tree failure at site 47, the tree deaths (as indicated by stumps) around sites 54 and 55, and the thin white fir crowns with slow growth at site 51 and 57 are the result of annosus infection. The dead tops in the white fir around site 51 are caused by true mistletoe and the fir engraver. Suggest boring and evaluating thin-crowned fir for butt and root decay. Consider removing thin-crowned fir, releasing the cedar and replanting open areas with pine and/or oak.

Site 39 - The dead 8" dbh white fir next to the table is infested with fir engraver larvae. Consider removing this tree.

Site 59 - The stocking around this old-growth specimen tree is too high. Some of the younger pines have broken tops and the more severely damaged pines are susceptible to bark beetles. Consider removing pines with broken tops.

Site 60 - Large old-growth sugar pine with one side of the lower bole severely decayed. Planned for removal.

Site 62 - Across the road from this site is a 30" dbh white fir with 2 dwarf mistletoe-caused bole cankers. Both are open to decay and have a high potential for failure. Consider removal.

Site 64 - Oak being topped by conifers. Consider partial release by removing some conifers. Dwarf mistletoe in white fir in this area is not a problem but you should be aware of this for future management.

Site 67 - At the back of this site a 12" dbh white fir is leaning over the site. Check and consider removal. Across the road from this site are 1) a large 48" white fir with a broken and rotten top with a new bayonet top. A 40" dbh white fir with a fire scar sounds quite hollow. Evaluate both for hazard.

Site 69 - A large 50" dbh white fir with a fire scar and a large goose pen with decay. Should be bored and evaluated for hazard. Dogwood canker of unknown cause is killing large dogwood stems in this area.

Site 70 - Dwarf mistletoe-caused bole cankers in a large and a small white fir on this site. Examine and evaluate for hazard.

Site 71 - Large dead white fir is a probable hazard. Remove.

Picnic Area - In general the stand covering this area is overstocked. There are several large old white fir with large fire scars. Should have these bored and evaluate for hazard.

River Trail - At the head of the parking lot next to the River Trail the large old-growth white fir has several Echondontium tinctorium conks, indicating extensive heart rot of the trunk. There is a strip kill on one side of the bole and flatheaded borers are working in the cambium at the strip's margins.

Squaw Hollow Campground

This campground consists of a rather uniform stand with an old-growth canopy of white fir, scattered incense-cedar, and an occasional sugar and ponderosa pine. There are several areas with sapling-size and larger trees in the understory. Bigleaf maple is relatively common along the creek and minor numbers of dogwood and black oak are present. The vegetation in Squaw Hollow corresponds most closely to Stands D and F that were described for North Grove Campground.

The major factors contributing to mortality and hazardous trees in white fir include dwarf mistletoe bole cankers, heartrot, annosus root disease and Armillaria root disease. Conditions that are adversely affecting all conifer species are heartrots and overstocking. In several instances hardwoods are being overtopped and shaded out by conifers. The biologies of all pests mentioned are described in Appendix I.

Large white firs with old dwarf mistletoe bole cankers are scattered throughout the campground. Not all of these trees are currently hazardous but they should be watched closely and periodically for signs of decay. When an open canker occupies more than half a tree's circumference, the tree should be considered hazardous and a candidate for removal.

Seven Fomes annosus root disease centers were identified by finding conks inside old stumps. This root pathogen is very damaging in true fir stands, acting as a root and butt rot. Firs with advanced decay do not always exhibit external symptoms. White fir on the periphery of these known root rot centers should be monitored carefully, and any of them that show other defects such as severed roots, lean, or a thin off-color crown could fail at any time.

Armillaria root disease, caused by Armillariella mellea, was involved in killing small white firs in locations with saturated soils. The soil at Sites 110, 112, 116, 118, 119 and 120 is very wet, especially during spring, and this water-logged condition allows weakened trees to be infected by A. mellea. This fungus infects roots, grows in the cambial region, and if it reaches the root collar, it can girdle and kill the tree. Presently small trees are being killed, but the roots of larger trees are probably also infected. If the problem of poor drainage is not corrected, smaller trees will continue to die and larger trees may eventually decline, die or fail.

As in North Grove Campground, we observed large specimen trees surrounded by a dense understory. Numerous locations are too heavily stocked with sawtimber-size trees, even for the excellent site quality in the campground. Many aggregations have over 400-500 square feet of basal area per acre. Each of these situations places all the vegetation under stress and will eventually cause trees to be successfully attacked by bark beetles or other pests. No pine engraver beetles were seen at Squaw Hollow, but conditions that could cause an increase in their numbers and damage were present.

The minor pests found at Squaw Hollow include Elytroderma needle disease on ponderosa pine, true fir needle cast (caused by Lirula abietis - concolorus) on white fir, and true mistletoe on white fir. None of these diseases is currently killing trees or creating hazards. Elytroderma needle disease and true mistletoe were seen on only a few trees. True fir needle cast, however, was quite visible on many white fir saplings along stream banks and in areas with a lot of soil moisture (principally Sites 112, 113, and 128). This disease, by itself, does not kill trees unless defoliation occurs for several consecutive years, but it may reduce tree vigor enough to allow infection of tree roots by Armillaria root disease.

MANAGEMENT ALTERNATIVES - SQUAW HOLLOW

1. No change in management. At the current level of vegetation management we would anticipate long-term increases in 1) basal areas, 2) competition/stress, 3) insect-related mortality of conifers, 4) sizes of root disease centers, 5) root disease-related mortality or failure of true fir, and 6) the proportion of true fir and incense cedar. Over the same period the proportion of pine and oak in the campground and the number of viable management options available to the Park will decrease.

2. Thin overstocked aggregations. The major effect of reducing basal area is to increase tree vigor and reduce the probability of successful bark beetle attacks. Although site quality at Squaw Hollow is excellent, many areas are still stocked at levels greater than the land is capable of supporting indefinitely. Heavily stocked stands of old growth true fir are particularly favorable to develop serious annosus root disease problems. From a pest management standpoint, basal areas around 300 sq.ft./A or less are much more desirable than 400-500 or even more.

3. Use protective insecticide sprays. High-value pines may be treated with residual bark sprays that will prevent successful bark beetle attacks. This treatment is not a substitute for dealing with the factors that predispose pines to bark beetles, but is more appropriate when valuable pines are under temporary stresses such as recent mechanical injuries or drought.

4. Reduce Fomes annosus impact. This root disease is only affecting the white fir component in Squaw Hollow. The method we used to locate root disease is conservative and undoubtedly under-estimated the actual number of infection centers present. Several approaches to control are available.

a) Prevent stump infection. The Park routinely treats all cut conifer stumps with borax, and we certainly encourage continuation of this practice because it will prevent the start of new infections. It does not, however, affect the enlargement of established centers.

b) Favor resistant species. The conditions in Squaw Hollow indicate that all pines and hardwoods will not be infected in current disease pockets; incense cedar is questionable but probably also resistant. These trees may either be retained if already present in or around annosus centers or be planted in centers. Planting pines and hardwoods may also help to slow, stop, or reverse the natural shift from pine-hardwood to fir-cedar.

c) Remove stumps. Fomes annosus can remain viable in stumps and roots for decades, making the area unsuitable for true fir. Removing stumps in and around disease centers will eliminate much of the root disease inoculum from the soil. This treatment has been used elsewhere for other root diseases in the West, but to date its efficacy has not been demonstrated in California.

5. Favor hardwoods. Some of the hardwoods in the campground are showing the effects of competition and shading from conifers and, therefore, are slow growing, declining, and may eventually become hazardous. Releasing these hardwoods would extend their lifespan. Also, hardwoods are valuable from a pest management standpoint because they present a barrier to the spread of dwarf mistletoes and annosus root rot. Hardwood trees and shrubs can also be planted in Fomes annosus centers and other openings.

6. Remove hazardous and high-risk trees. Old-growth specimen trees are almost always wanted in campgrounds because of their aesthetic value. Sometimes thinning around such trees will increase their vigor, but in other cases, trees showing obvious symptoms of low vigor, disease, injury, dieback or decline are likely to be killed by insects.

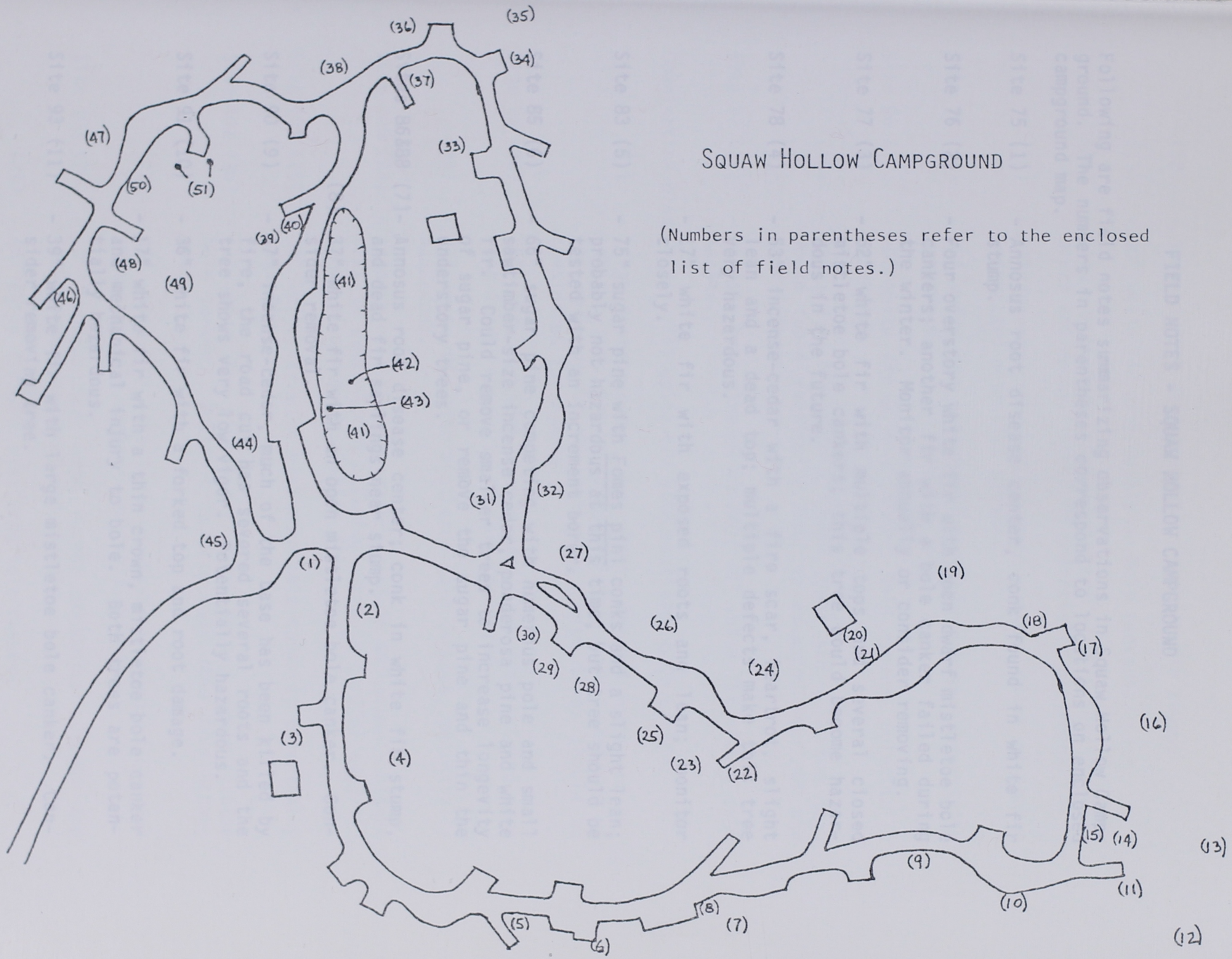
Hazardous trees are currently evaluated biennially in the Park. We identified trees in Squaw Hollow that were potentially hazardous (see enclosed map and field notes) but did not judge which should be removed. The two major sources of failure are dwarf mistletoe bole cankers and annosus root disease - both affecting only white fir. Particular attention should be paid to large fir in root disease centers because they may fail without showing any obvious signs of advanced root decay.

One improvement in the Park's hazard tree program would be to identify, map, and record data on all trees that are considered hazardous to some degree. This would allow the inspector or other Park personnel to determine whether any trees had become more hazardous since the last inspection, and would also provide feedback information on the types of defects that most often lead to tree failure under the environmental conditions at Squaw Hollow.

7. Treat pine slash. Any actions that create green pine slash during winter and spring could result in the buildup of damaging pine engraver (Ips) beetle populations. Slash resulting from storm breakage, windthrow or any tree cutting should not be left untreated in the campground. In addition to removing the slash, other treatments include, chipping, burning, mechanical crushing, debarking, and lopping and scattering slash in sunny locations.

8. Modify drainage patterns. Procedures such as ditching or installing drainage tiles could be used to reduce the high soil moisture in several campground areas. Improving drainage would certainly reduce the number of trees being killed by A. mellea and also make affected campsites useable much earlier in the spring.

Any or all of alternatives 2-8 would be appropriate and beneficial to the campground depending upon each particular situation and the objectives and priorities of the Park.



Squaw Hollow Campground

(Numbers in parentheses refer to the enclosed list of field notes.)

FIELD NOTES - SQUAW HOLLOW CAMPGROUND

Following are field notes summarizing observations in Squaw Hollow Campground. The numbers in parentheses correspond to locations on enclosed campground map.

Site 75 (1) - Annosus root disease center, conk found in white fir stump.

Site 76 (2) - Four overstory white fir with open dwarf mistletoe bole cankers; another fir with a bole canker failed during the winter. Monitor annually or consider removing.

Site 77 (3) - 62" white fir with multiple tops and several closed mistletoe bole cankers; this tree could become hazardous in the future.

Site 78 (4) - 53" incense-cedar with a fire scar, heartrot, slight lean and a dead top; multiple defects make this tree very hazardous.

- 17" white fir with exposed roots and lean; monitor closely.

Site 83 (5) - 75" sugar pine with Fomes pini conks and a slight lean; probably not hazardous at this time, but tree should be tested with an increment borer.

Site 85 (6) - 66" sugar pine competing with numerous pole and small sawtimber-size incense cedar, ponderosa pine and white fir. Could remove smaller trees to increase longevity of sugar pine, or remove the sugar pine and thin the understory trees.

Sites 86&88 (7)- Annosus root disease center; conk in white fir stump, and dead fir saplings near stump.

(8)- 37" white fir with an open mistletoe bole canker. Consider removal.

Site 90 (9) - 47" incense-cedar, much of the base has been killed by fire, the road cut has severed several roots and the tree shows very low vigor. Potentially hazardous.

Site 91 (10) - 36" white fir with a forked top and root damage.

- 17" white fir with a thin crown, mistletoe bole canker and mechanical injury to bole. Both trees are potentially hazardous.

Site 93 (11) - 39" white fir with large mistletoe bole canker. Consider removing tree.

(12) - Annosus root disease center; conk in fir stump.

(13) - 30" white fir with mistletoe bole cankers.

(14) - Three overstory incense-cedars with extensive fire scars and decay. Could be potentially hazardous.

(15) - 22" incense-cedar with a bole canker; cause of canker and hazard potential unknown.

Site 95 (16) - 39" white fir with mistletoe bole canker; potentially hazardous.

Site 96 (17) - 40" white fir with mistletoe bole canker; potentially hazardous.

(18) - 42" white fir with a large wound and a forked top. Wound could eventually lead to advanced heartrot and tree failure.

Site 97 (19) - Annosus root disease center; 35" white fir with a conk inside.

Combination Bldg. (20) - 35" white fir with mistletoe bole canker.

(21) - large incense-cedar, low vigor, damaged roots and extensive fire damage to 1/2 of tree base. Because of the nearness to the building, these trees should be considered for removal.

Site 99 (22) - 33" white fir with root damage from road cut and some root decay; should be closely monitored.

(23) - 27" white fir with mistletoe bole cankers, potentially hazardous.

Site 100 (24) - Annosus root disease center; conk in 49" stump. Closeness to combination building warrants careful surveillance of surrounding white fir.

Site 101 (25) - 36" white fir with mistletoe bole cankers; potentially hazardous.

Site 102 (26) - 42" white fir with basal scar, decay, and mistletoe bole canker. Multiple defects make this tree hazardous.

(27) - 35" white fir with large mechanical wound, decay and mistletoe bole canker - multiple defects.

Site 103 (28) - 18" incense-cedar with recent mechanical damage and lean; should be monitored closely.

(29) - 46" white fir with mistletoe bole canker.

(30) - 49" incense-cedar, low vigor, 1/2 of the base is burned away, top dead, excessive lean. Multiple defects make this tree hazardous.

Site 105 (31) - Armillaria root disease killing saplings and pole-size white fir; predisposing factor is probably saturated soil.

(32) - an example of overstocking; the basal area of this white fir aggregation is almost 500 sq.ft./acre.

Site 110 (33) - Annosus root disease center, 2 white fir stumps with conks.

Site 112 (34) - Armillaria root disease killing saplings and pole-size white fir; the predisposing factor is water-logged soil. Lirula needle cast is causing premature defoliation of small white fir.

(35) - 53" incense-cedar with some decay at base; excessive lean toward campsite makes this tree hazardous.

Site 113 (36) - Hardwoods are being crowded out by conifers; Armillaria root disease could result.

Site 114 (37) - 52" incense-cedar with severe fire damage to base and roots.

Area between sites 113 and 128 (38) - Sapling white fir along stream are being defoliated by Lirula needle cast.

Site 115 (39) - 36" ponderosa pine with Elytroderma needle cast on 25% of crown; not hazardous or serious at this time.

(40) - Single sugar pine with Fomes pini conks; tree has an average of only 2" of sound sapwood although it is growing well; tree should be bored periodically to check amount of heartrot.

Sites 116-120 (41) - Entire area has excessive water and saturated soil, Armillariella mellea is present; several trees have fallen in past years; 4 white fir saplings died recently; numerous stumps present (incense-cedar, white fir, and black oak). The only solution is to alter drainage pattern.

(42) - incense-cedar with fire damage and slight lean; because of soil moisture problem and root disease fungi this tree may be very hazardous.

(43) - 31" incense-cedar almost dead; leans toward parking pad - tree very hazardous.

Site 119 (44) - 2 white fir saplings dead from Armillaria root disease and soil moisture.

Site 121 (45) - 42" white fir with a hollow butt and dead top. Consider removing.

Site 124 (46) - 16" white fir with mistletoe bole canker.

Site 125 (47) - Annosus root disease center; stump with conks, white fir adjacent to stump recently failed.

Site 126 (48) - 2 dead pole-size white fir - cause of death undetermined.

(49) - 63" incense-cedar; extensive fire damage to base and roots; along stream; leans toward campsite. Potentially hazardous.

(50) - 14" white fir with dead top and declining crown.

Site 127 (51) - 2 overstory white fir with recently killed dead tops; tops will eventually become hazardous.

Site 128 (52) - Annosus root disease center; conks in 55" white fir stump.

FIELD NOTES - BIG TREES TRAIL

Following are the field notes of our observations along the North Grove Big Trees Trail.

- Next to the trail and just below the Ampitheater there is a large forked sugar pine. Fomes pini is fruiting abundantly on one fork, indicating extensive decay. Should bore and evaluate for hazard.

- Just before the big tree stump there is a white fir with excessive lean and lifting root ball. Should be evaluated as a hazard.

- Just past the big tree stump is a 36" dbh white fir snag which needs a hazard evaluation.

- Along the first 1/2 of the trail we encountered numerous trees which we considered predisposed to failure by annosus root disease and dwarf mistletoe-caused bole cankers, and several dead standing snags. All these situations need a hazard evaluation which considers the probability of failure and the probability of trail occupancy. One can see the numerous fallen trees in the area which attest to the frequency of tree failure in the area. The second half of the trail had a much lower incidence of trees with predisposing defects.

APPENDIX I

BIOLOGY OF PEST ORGANISMS

WESTERN PINE BEETLE

Dendroctonus brevicomis attacks only ponderosa pine at Calaveras Big Trees State Park. It will breed only in the bole of living trees that are over 6 inches in diameter. Normally this beetle breeds in trees that are overmature or have been weakened by drought, stand stagnation, injury or root disease. An attractant, called a pheromone, is released by the western pine beetle when a tree is successfully attacked. This draws more western pine beetles toward the tree under attack. If a large number of beetles land on nearby apparently healthy trees, they may be able to overwhelm them and cause a group kill.

Initial attacks are made about mid-bole and subsequent attacks fill in above and below. Small pink pitch tubes may form at the mouth of the entrance hole. The adults bore winding egg galleries in the cambium. Larvae feed in the inner bark for a short distance and complete their development in the outer bark. Adults emerge and initiate attacks beginning in late spring and continue through fall. Two or three generations per year could be produced in the Park.

Individual ponderosa pines which undergo a temporary and reversible stress such as drought or fire scorch can be protected from attack for a period of up to a year by applying insecticide to the bole. Area-wide losses can be minimized by measures such as thinning to promote tree vigor and increase resistance to attack.

RED TURPENTINE BEETLE

Dendroctonus valens breeds in all species of pines. It normally attacks injured, weakened or dying trees and freshly cut stumps. It is quite common on pines scorched by fire or infected by root disease. Campground trees with trunk injuries or which have soil in the root zone compacted by heavy foot traffic or vehicles are also susceptible.

There is usually a large reddish pitch tube produced at the point of entry. Attacks usually occur within two feet of the soil line but may extend to a height of 10 feet on trees under severe stress. Adults excavate a short, irregular gallery between the bark and wood beneath the point of entry and lay eggs. The larvae feed as a group and destroy the cambium in an area ranging from 0.1 to 1 square foot. Single attacks have relatively little effect on a tree. Multiple or repeated attacks can kill a tree or make it susceptible to attacks by other bark beetles.

Attacks occur throughout warm weather but peak by mid-summer. There would be one or two generations per year at the Park.

PINE ENGRAVERS

The pine engraver beetles (Ips spp.) are common throughout western North America. They are most commonly found attacking freshly cut logs, slash, breakage, tops, and limbs of all pine species. Attacks on tops and limbs may precede or occur in conjuction with attacks by bark beetles. When suitable host material is plentiful, such as slash or drought-stressed pines, large numbers of engravers may develop in this slash and then attack healthy green pines. Young pines 2-8 inches dbh and the tops of older trees are the host material most at risk. This is particularly true of densely stocked groups of trees. Fortunately, outbreaks are usually of short duration and seldom last more than one season.

Attacking adults may be found under the bark constructing a typical three- or four-pronged egg gallery from a central nuptial chamber. These galleries run parallel to the wood grain and assume a Y or H pattern. The galleries are kept clear by the adults, and consequently the reddish boring-dust accumulates near the entrance holes. The dust is particularly visible on horizontal host material such as blowdown; on standing trees it catches on bark flakes, crevices, and spider webs. In the area of the Park two or three generations can be expected per year -- two summer generations following spring emergence of adults, and possibly a third that will overwinter as adults.

Standing trees can be protected by preventing a local build-up of engraver beetles in green pine slash. Winter snow breakage or slash from thinning would be suitable host material. Slash which is produced from late January through early July would contribute the most to building up potentially damaging populations. Infestation can be prevented by modifying the slash by chipping the slash or burning it while still green. Localized areas such as campgrouds could be offered some protection by hauling green pine slash off the site, because adults normally fly less than a quarter of a mile from where they emerge before initiating an attack.

FIR ENGRAVER

The fir engraver, Scolytus ventralis, attacks most true fir species in the western United States, including white and red fir. Attacks can result in a) tree mortality, b) top-kill or c) patch kill along the bole. Trees ranging in size from larger saplings to over-mature saw timber may be attacked. Top-kill and mortality are often associated with hosts that have been weakened or stressed. Factors contributing to such stress include root disease, heavy dwarf mistletoe or true mistletoe infection, overstocking and drought.

It takes one year for the fir engraver to complete a life cycle. Adults fly and attack trees or green fir slash from June to September; larvae, pupae and adults overwinter under the bark. Pitch tubes are not formed, as is frequently the case with pine bark beetles, but unsuccessful attacks are often characterized by pitch streamers on the mid and upper bole. Trees successfully attacked early in the summer may begin to fade by early fall, but trees attacked later in the year will probably not

begin to fade until the following spring or summer, and the beetles may have emerged by the time the tree fades. Direct control of the fir engraver is usually impractical due to the widespread, sporadic occurrence of mortality, top- and patch-kill.

ANNOSUS ROOT DISEASE

Fomes annosus is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible to the fungus. Hardwood species are rarely infected. New infection centers begin by aerial spread of spores and subsequent colonization of freshly cut stump surfaces and/or basal wounds. The fungus then spreads via root contacts into the root systems of adjacent live trees. In pines, it grows through root cambial tissue to the root crown where it girdles and kills the trees. In non-resinous species, such as true firs, the fungus sometimes kills trees, but more frequently it is confined to the heartwood and inner sapwood of the larger roots where it causes a butt rot and reduced tree growth. Thus, while infection in true fir usually does not kill the host, it does affect its growth and thriftiness. Losses in true fir from F. annosus are mainly the result of butt rot, windthrow resulting from root decay, and predisposition of trees to attack and eventual death by bark beetles and flatheaded and roundheaded borers.

Vigorous young firs are usually able to regenerate root tissue faster than they are lost to the root disease. But when true firs slow in growth because of stand and/or site conditions, root development decreases to where there is a net loss in roots and the trees slowly decline due to the gradual loss of their root systems.

Borax stump treatment is used routinely for the prevention of infection in conifers in recreation areas. Incidence of F. annosus is somewhat higher in older, larger fir and in stands with high basal areas (over about 330 square feet/acre). Therefore, removal of old-growth fir and thinning of overstocked stands to increase tree vigor may reduce the impact of the disease, given that the residual trees are capable of responding to release.

ARMILLARIA ROOT ROT

Armillariella mellea is a fungus which causes a root and root collar decay of more than 600 species of conifers, hardwoods, shrubs and herbaceous plants. After the fungus has developed in an infected tree, using the dead stump or root as a food base, it produces structures called rhizomorphs, or strands of fungal tissue. Rhizomorphs formed on decayed wood or diseased trees grow through the soil like roots and may infect surrounding living trees, especially young conifers. When the rhizomorph comes in contact with a nearby susceptible root, it adheres and penetrates through the bark to the cambium region. The fungus grows in the cambial area and produces a white, flat, leathery, fan-shaped mycelial mat. A network of rhizomorphs is often associated with the mat. From the mats the fungus penetrates xylem tissue and produces a white to yellowish stringy rot that is often accompanied by fine black zone lines.

Armillariella mellea is present in most forests and is usually prevalent where oak is a stand component. Since the fungus exists in most soils, successful infection is usually related to low tree vigor. Death or decreased vigor of oaks allows the fungus to penetrate, decay tissues, and form rhizomorphs. Oak stumps provide a food base for the fungus which is essential for the production and growth of rhizomorphs through the soil. Therefore, the presence or creation of dead oak roots/stumps increases the probability of infection of surrounding conifers by rhizomorphs of the fungus. Stumps and roots infected with A. mellea act as disease centers as long as they provide a suitable food base for the rhizomorphs. Mortality of young conifers will probably not begin until four to five years after oaks are killed, but, once it begins, mortality may continue for five years or more. If overmature oaks, which are hazard trees, are to be removed from campgrounds, treating them so that they decline gradually rather than rapidly will reduce the amount of food base available at any one time. Removal of stumps will also decrease the food base available.

TRUE FIR DWARF MISTLETOE

The dwarf mistletoes are parasitic seed plants which are generally host specific. Red fir dwarf mistletoe (Arceuthobium abietinum f. sp. magnificae) infects red and noble fir. White fir dwarf mistletoe (A. abietinum f. sp. concoloris) infects white and grand fir. The dwarf mistletoes are obligate parasites which are completely dependent on their host for support, for water, and for most of their mineral and organic nutrients. Infection of trees by dwarf mistletoe results in reduction of growth, growth abnormalities, mortality, and predisposition to other pests. Open bole swellings resulting from dwarf mistletoe infections provide entrance courts for insects and decay fungi and weaken the tree at that point, making them prone to wind breakage.

Dwarf mistletoes spread between trees and within crowns of trees by means of small seeds that are forcibly ejected into the air. A period of 3 to 6 years elapses between initial infection and shoot production. Spread from overstory to understory trees is limited to the distance traveled by the seeds. The lateral distance that seeds are dispersed is given by the rule of thumb: maximum distance potential is equal to the height of the dwarf mistletoe plant above ground. Lateral spread of the parasite in an even-aged stand is probably somewhat less than 1 to 2 feet per year while the vertical spread within the crown averages 3 inches per year. In practical terms, the long life cycle and slow rate of spread means that the buildup of dwarf misteltoe in a stand is relatively slow. True fir saplings and poles growing more than about one foot or more in height per year, and free from a source of overstory infection, will outgrow the effects of any dwarf mistletoe.

WHITE FIR TRUE MISTLETOE

The true mistletoes are usually considered to be curiosities, but they can be serious pests where individual trees are of high value. Species of Phoradendron are considered "water parasites" and are less demanding of their hosts than the dwarf mistletoes. The white fir true mistletoe (Phoradendron bolleanum subsp. pauciflorum) infects only white fir.

True mistletoe infections are spread mainly by birds - including robins, blue-birds, thrushes, and cedar waxwings - that feed on mistletoe berries. Birds digest the pulp of the berries and excrete the living seeds, often depositing them onto susceptible trees. A viscous coating and hair-like threads on the outer surface of the seeds enables them to become firmly attached to twigs and branches, where they germinate and infect the host tissues.

Young or small trees are seldom infected. In nearly all cases, initial infection occurs on tall or older trees, because birds prefer to perch in their tops. Severe buildup of mistletoe, which occurs over a period of many years, often occurs in an already-infected tree because birds are attracted to, and may spend prolonged periods feeding on, the mistletoe berries.

Trees heavily infected by true mistletoe are weakened, reduced in growth rate, and sometimes killed. Spike tops, common in white fir infected with the parasite, are susceptible to decay and breakage and hence are considered hazardous in high-use sites. Weakened trees are predisposed to attacks by insects and often die during drought or other periods of stress.

ELYTRODERMA DISEASE

Elytroderma disease is caused by Elytroderma deformans, a fungus which infects mainly Jeffrey and ponderosa pines. It has also been reported on knobcone, lodgepole, and pinyon pines. The disease is spread by spores which are dispersed from small fruiting bodies produced on infected needles. After the spores infect current year's needles, the fungus becomes systemic in twigs and buds. This perennial bud infection serves to reinfect each year's needles as they grow out and causes them to die and drop off the second year. Infected twigs retain only the current year's needles. The sytemic infections also produce "witches' brooms" similar in appearance to witches' brooms produced by dwarf mistletoes.

The disease may cause significant growth loss when more than 40% of the crown is infected. The impact of the disease can be reduced by removing trees with more than 40% of the crown infected and by favoring resistant species. Although direct killing of mature trees is infrequent, moderate to severe infection predisposes the tree to other diseases and to bark beetle attack. In areas such as the North Grove campground where infection is generally light, pruning of brooms may restore the vigor of weakened trees.

DOGWOOD CANKER

Four fungi -- three Nectria spp. and Phytophthora cactorum -- are known to cause cankers on dogwood. We did not identify the organism causing the cankers at North Grove, but the symptoms were similar to those described for P. cactorum on ornamental dogwoods. This fungus was first reported on madrone and dogwood near Seattle in 1941, and subsequently was found elsewhere in the West. The canker fungus generally attacks at

the base of the stem, and occasionally at broken branch stubs. Infection is probably facilitated by the presence of moisture at the root crown and in crotches. The cankers grow faster vertically than laterally, and are first visible as sunken or water-soaked lesions. As the canker develops, a crack forms at the margin between the diseased and healthy tissue; eventually the tree is girdled and dies. Often the first indication of the disease to the casual observer is a rapid wilting of the upper crown, followed by browning of the leaves and death.

RED RING ROT

Red ring rot, also called white pocket rot, is caused by a wood decay fungus, Fomes pini, that attacks Douglas-firs, pines, true firs, larch, spruce, hemlock, western red cedar, and rarely incense-cedar. It occurs throughout the coniferous forests of the world, and is the single most damaging heart rot organism in the West.

Red ring rot attacks young-growth as well as old-growth trees. It usually infects through living and dead branches or branch stubs, and rarely through open wounds. Thus, this fungus may cause serious heart rot problems in managed stands of the future.

The perennial, woody fruiting bodies or conks that arise from the branch stubs or knots of living trees are the best indicators of decay. Sometimes only punky knots bearing the inner portion of the fruiting body remain on the stem. These punky knots may later be overgrown by new wood, becoming swollen knots that are the only symptom of decay. When conks or swollen knots are present, assume that advanced decay extends about 3-5 feet above and 5-7 feet below the indicator. If conks or swollen knots are visible along much of the length of the stem, heart rot will be extensive.

TRUE FIR NEEDLE CAST

This foliage disease is caused by the fungus Lirula abietis-concoloris, and may be found wherever true firs grow. Only one year's needles are attacked in a season and, therefore, trees are not normally killed unless there are several consecutive years of infection.

The life history of this fungus is not well understood, but it is thought to take 2 years from first infection until fruiting structures (hysterothecia) mature. Hysterothecia are quite conspicuous and appear as a single, very thick brown or black line that runs almost the entire length of the needle on the underside.